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PERFORMANCE ASSESSMENT BATTERY (NMRI PAB)

DOCUMENTATION

AD-A201 654

John R. Thomas and John Schrot

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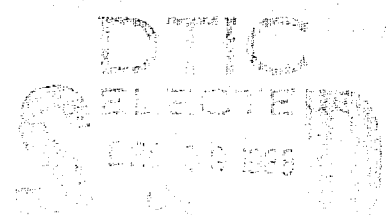ELECTE

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A cognitive performance assessment system developed for the evaluation of effects of operational Navy environments on performance is described. The performance assessment battery (NMRI-PAB) is made up of separate performance tests that each measure aspects of human cognitive functioning found to be important in critical tasks performed by Navy and Marine Corps personnel. The battery is designed to operate on a number of different standard microcomputer systems. The tests are administered by menu-driven computer programs and the administration of the battery can be learned easily by individuals not familiar with the performance assessment technology. The NMRI-PAB reflects a general methodology developed within a tri-service coordinated effort to provide standardized testing technology for the measurement of human performance in military environments. The report is a detailed description and specification of the assessment battery. Keywords:

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INTRODUCTION

Naval and Marine Corps personnel, in pursuing mission objectives, are often required to work under hostile and hazardous environmental conditions that may have either subtle or very profound effects on performance. These conditions can range from hazards such as temperature extremes or extremes of atmospheric pressure to toxic gas environments produced by combustion and fire to the intense stress produced by combat operations. The recent experiences of the U.S. Navy during operations in the Persian Gulf and of the British Navy during the Falklands Campaign indicate that human performance can be adversely affected by exposure to such conditions. Often the effects on performance of military environments are intensified by the addition of other interacting variables, such as medications, protective agents, and restrictive specialized gear. Measurement of effects of such variables on military performance requires the most relevant and technically modern procedures possible. More detailed analysis and precise quantification of performance effects will remain a continuing major military tasking concern.

The successful performance of mission essential tasks and objectives in military environments requires many of the same complex behavioral elements comprising many technically oriented

tasks. These elements include, but are not limited to: response accuracy, logical reasoning, speed and correctness of response acquisition, short-term memory, attention, spatial orientation, pattern matching, and color and form discrimination. Traditionally, measurement of operational environment effects on these elements has often been accomplished through the use of printed or stand-alone materials, testing for only single elements at a time. Such measurements have usually involved very time consuming and labor intensive settings.

In order to facilitate assessment of operational environment effects on performance the Naval Medical Research Institute Performance Assessment Battery (NMRI-PAB), a microcomputer-based human performance test battery, was developed. The NMRI-PAB reflects a general methodology developed within a tri-service coordinated effort to provide standardized testing technology for the measurement of human performance in military environments. Eight tests, based on research literature, that have been demonstrated to measure important performance characteristics were chosen to form the battery. The performance test battery was written in a modular computer programming language and is designed to operate on a number of different standard microcomputer systems. The individual performance tests that make up the assessment battery each measure some aspect of human cognitive functioning found to be important in critical tasks performed by Navy and Marine Corps personnel. The eight component tests of the battery are: the Matching to Sample test,

the Stroop test, the Grammatical Reasoning test, the Manikin test, the Numerical Memory test, the Pattern Comparison test, the Repeated Acquisition test, and the Visual Scanning test. The descriptions and specifications of these eight tests are presented in the present report. The tests are administered by a menu-driven computer program and their presentation is organized and controlled by the experimenter through an Executive program, also described in the present report. The battery takes approximately 30 minutes to administer and provides information about both speed and accuracy of responding. The implementation has many advantages over traditional methods of performance testing. Multiple subjects may be measured simultaneously, the detail of the data that can be collected and analyzed is greatly enhanced, the software defining the battery is easily modified and can be transported between laboratories or field sites via modem or floppy disk, and the battery can be administered by technical support staff.

A major benefit to the Navy of a performance assessment battery is availability of a standardized human performance assessment system that can readily be administered in a variety of Naval environments as well as a standardized data collection and analysis. The performance assessment methodology allows different Navy laboratories, engaged in various types of medical research involving measurement of human performance, to facilitate coordination and interaction among programs.

EXECUTIVE PROGRAM

General Description:

The individual tests of the NMRI-PAB are controlled and
organized by an overhead master program called the Executive
program. This program allows the experimenter to enter subject
information and dates, to direct the data collection to a
particular computer drive and file name, and to alter the length
of the NMRI-PAB and the sequence of test administration, if so
desired. The Executive program passes information to the
individual tests comprising the battery automatically through the
use of a 'common' computer program.

Detailed Description:

The test battery administrator invokes the NMRI-PAB by
typing the word, 'EXEC', at an appropriate work-station. The
Executive program text appears as white letters on a blue
background. The first screen to appear on the computer
identifies the NMRI-PAB on lines five through ten of a 24 line
screen. Line 13 requests the subjects name. Following the entry
of a name or ID, line 15 requests the current date, and line 17
requests the computer drive specification and file name where the

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data are to be written. All of this information is automatically stored and passed to the data files of individual tests.

Line 19 requests that a random seed number be entered. This can be any number between -32768 and 32767. This number will control the sequence of all random events throughout a session. By entering the same random seed number, the exact same sequence of random events can be repeated for a different NMRI-PAB session. This would allow different subjects, for example, to be exposed to exactly identical test sequences. The next line on the screen requests the number of the repeated acquisition sequence that is to be run during the current session. There are 24 different sequences to chose from. After the repeated acquisition sequence has been selected the following statements appear beginning on line 21:

The standard test sequence is Numeral Memory, Pattern Comparison, Grammatical Reasoning, Matching-to-Sample, Visual Scanning, Manikin, Repeated Acquisition and Stroop.

Do you wish to run the standard sequence? (Y or N)

As these lines are printed, the screen scrolls upward to accommodate the excess of 24 lines. A "Y" answer to this question (the Executive program accepts either an upper or lower case answer) automatically stores the standard test sequence of eight tests in the computer memory. The screen is then blanked

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and a 20 second inter-test-interval is initiated and is followed by the presentation of the first test.

All tests are preceded by a 20 second inter-test-interval that consists of a 14 second darkened screen followed by a 6 second 'traffic light'. During the 'traffic light', the screen is red for two seconds, yellow for two seconds, and then green for two seconds. This interval allows the subject time to attend and prepare for the next test.

A 'N' answer to the standard sequence question results in the screen being cleared and the following question appears on line 10 prompting the experimenter to select his own test battery configuration:

'Type the number of tests to be administered (1 to 8) :'

An answer between 1 and 8 defines the number of individual tests to be administered, clears the screen and presents, beginning on line 5 a table showing the eight tests available for selection and the number associated with each test. A statement appearing on line 20 asks the administrator to:

'Enter the number of the 'Nth' test'

Each response to this statement increments the number of the 'Nth' test requested until the number equals the number of tests to be administered. These selections are stored in computer

memory using the same procedures involved in defining the standard sequence. Upon identifying the number of the last test to be administered, program control is transf red to the first test of the battery. The screen is blanked and the first 20 second inter-test-interval commences.

The Executive program can be aborted at any point by typing the "Break key" or "Control-C" on the work-station keyboard. These keys will not terminate any of the individual tests, which each last for either a specified number of trials or a specified duration.

The information obtained with the Executive program (subject information, file name, battery length and composition etc.) is passed on to the individual test program files. A small computer program, called "common", is incorporated into the Executive and each of the test program files. The common program contains a list of all the variables that are defined during the Executive program and that are required by the individual tests in order to pass program control, open files, write data and identify the data. This is all accomplished automatically without input from the experimenter.

MATCHING TO SAMPLE TEST

Test Function:

The function of the Matching to Sample test is to measure short-term spatial memory and pattern recognition abilities.

General Description of Test:

Matching to sample is a test in which the subject is required to respond correctly to one of several stimuli that correspond in some fashion to a sample stimulus (Skinner, 1950). The subject is instructed to respond by pressing one of two buttons that indicate which of two stimuli is the same as a previously presented sample stimulus.

A single matrix is initially presented in the center of the screen as the sample stimulus. The matrix measures 4 by 4, consisting of sixteen cells displayed in each of two colors, red and green. For each trial presentation of a matrix, the number of cells that may be of the same color vary at random from only one cell through fifteen cells. The subject presses a center response button while the sample stimulus is present and the sample stimulus is removed from the screen. Following a brief delay, two separate matrices are presented, side by side, on the

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screen. One is identical to the sample matrix and the other matrix differs from the sample matrix by one cell. The subject is required to press either a right response button or a left response button to indicate whether the right matrix or the left matrix matches the preceding sample matrix.

A single trial consists of presenting the sample stimulus followed by the presentation of the two comparison stimuli and obtaining the subject's response. A test consists of a number of these trials, defined as a total number of trials or a specified total time.

Detailed Test Information:

The sample stimulus is a 4 by 4 matrix that measures approximately 3.5 cm wide and 3 cm high and is presented on a black background in the center of the screen. The sample matrix is filled with sixteen red and green cells. The matrix and the cells are outlined by thin, yellow line borders. A representative sample stimulus is shown in Figure 1. The color of each of the sixteen cells for each sample stimulus presentation is determined randomly. The color of the sixteen cells can vary from one cell red and fifteen cells green, to fifteen cells red and one green. The only restriction is that at least one cell be of the other color. The sample stimulus matrix is displayed at the start of a trial and remains on the screen until the subject makes a response on the center response button.
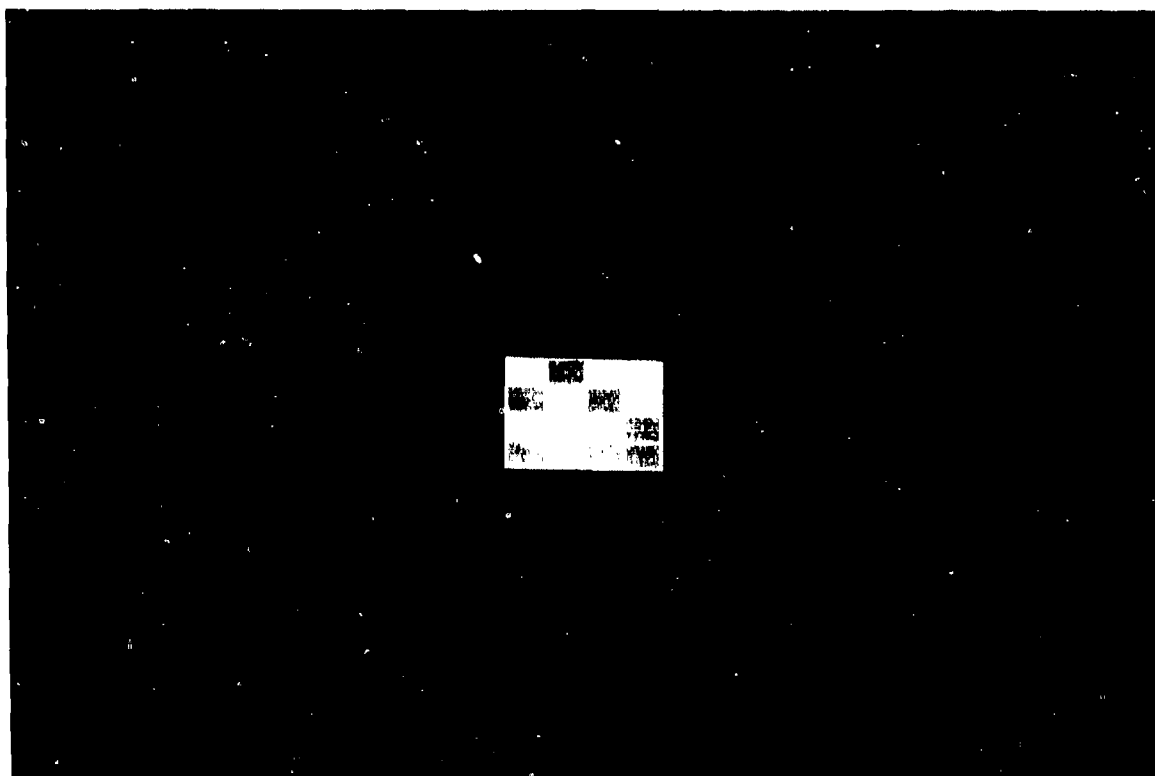
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Figure 1.   Representative sample stimulus for the Matching to Sample test. This figure and all figures are photographs of the computer screen.

The stimulus matrix is presented in completed structure such that the subject does not see the matrix constructed (drawn and painted) on the screen. The screen is cleared (completely dark) after a center response, and following a 1.5 second delay interval, two comparison stimuli are presented on the screen. One of the stimuli is a 4 by 4 matrix that is identical to the sample matrix and the other stimulus is a 4 by 4 matrix that differs from the sample matrix by one cell. The two comparison stimuli that are presented following the sample stimulus of Figure 1 are shown in Figure 2. The cell that is changed in the other comparison stimulus matrix to make it differ from the sample matrix is determined randomly.

The two comparison stimuli are presented side by side with approximately 3.5 cm distance between them. The distance between the two matrices is exactly the space on the screen that was occupied previously by the sample matrix. The comparison matrix that is identical to the sample matrix appears on the right side of the screen for half of the trials and on the left side of the screen for half of the trials as arranged by a random determination. The subject is required to respond on the left response button if the matching matrix is on the left and is to respond on the right response button if the matching matrix is on the right. Following the occurrence of a left or right response, the screen is cleared for one second, and then the sample stimulus for the next trial is presented.

A single trial consists of presenting the sample stimulus, a
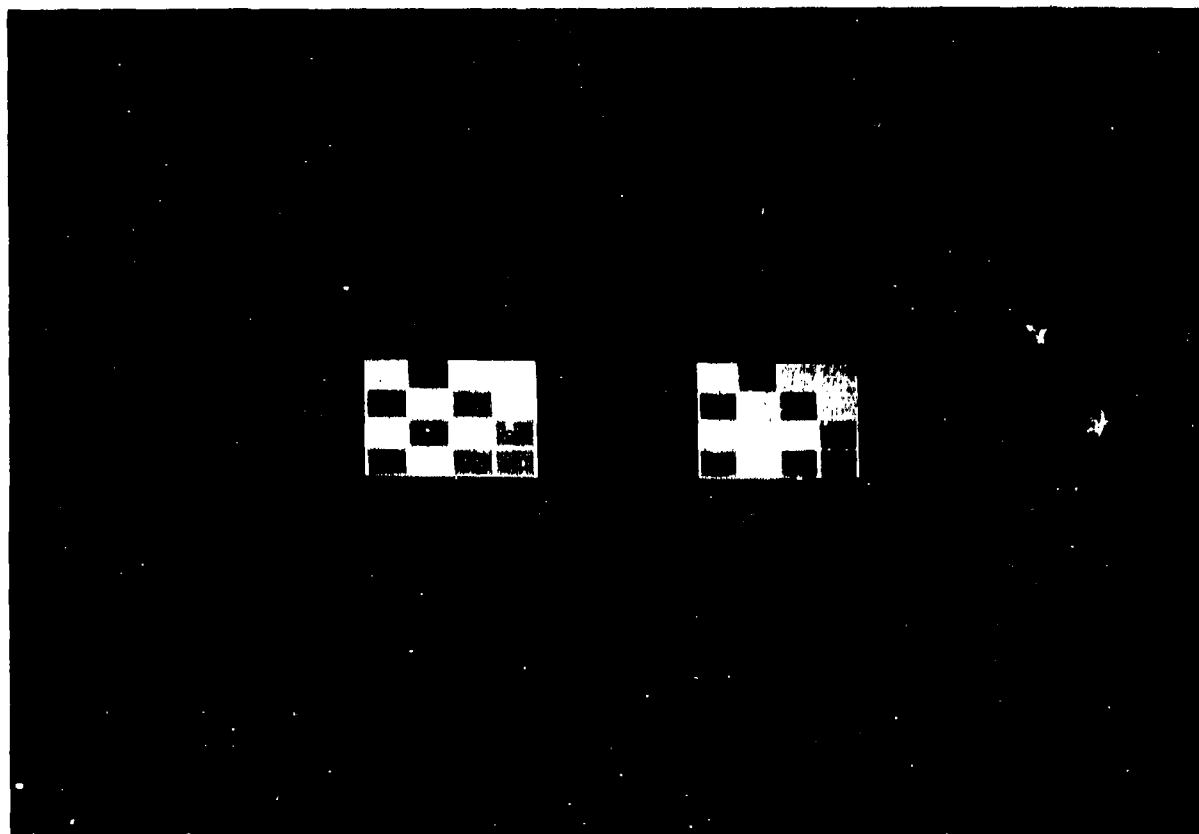
Figure 2. Representative comparison stimuli for Matching to Sample test.

center button response, presenting the two comparison stimuli, and either a right or left button response. A test lasts for 30 trials or 5 minutes, whichever occurs first. If a center button response does not occur in the presence of the sample matrix within 60 seconds, the two comparison stimuli are automatically presented, as if a response had occurred.

For each trial the time (in hundreds of seconds) that a stimulus is presented on the screen and the time of a subject's response is recorded. The time of stimulus presentation and subject's response is recorded separately for the sample stimulus and the comparison stimuli. The correctness of the subject's response is recorded as well as the actual button (left or right) that the subject pressed.

Also recorded for each trial is the 4 by 4 color configuration of the sample matrix, the configuration of the incorrect or differing matrix, and the location of the correct comparison matrix (right or left). A recorded session data file also contains the subject's name or ID, the date, and the number of trials completed. The recorded information can be used to generate the following data analysis: percent correct responses, mean and median response latencies, range and variability of response latencies, test start time, and test end time.

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STROOP TEST

Test Function:

The function of the Stroop test is to measure susceptibility to response-competition interference.

General Description of Test:

The test is based upon the procedures developed and described by Stroop (1935) and more recently by Flowers and Stoup (1977). During this test single words displayed in different colors are presented one at a time on the screen. The subject is instructed to respond by pressing a button that indicates the correct word or color.

There are three versions of this test that are available. Each version can be selected by setting a variable in the computer program. The three versions are: word relevant, color relevant, and control.

In the word relevant condition, the words 'red', 'green', and 'blue' are randomly presented and each of the words is displayed in either a red, green, or blue hue. The subject's task is to attend to the meaning of the word and not the hue in which the word is displayed. The subject is required to press

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one of three buttons on the response panel that is the same color
as the meaning of the displayed word.

In the color relevant condition, the words 'red', 'green',
and 'blue' are also randomly presented and each of the words is
displayed in either a red, green, or blue hue. The subject's
task is to attend to the hue of the word and not the word itself.
The subject is required to press one of three buttons on the
response panel that is the same color as the hue of the displayed
word. The color relevant condition is the standard default
condition presented in the NMRI-PAB.

In the control condition, the words, 'red', 'green', and
'blue' are also randomly presented but all of the words are
displayed in a white hue. The subject's task is to press one of
three buttons on the response panel that is the same color as the
meaning of the displayed word.

A single trial consists of presenting a single word in one
of the display colors and obtaining the subject's response. A
test consists of a number of these trials, defined as a total
number of trials or a particular total amount of time.

Detailed Task Information:

A single trial consists of the presentation of a word and
the subject's response. A test lasts for 45 trials or 3 minutes,
whichever occurs first.

In all three versions, the stimulus is one of three words,

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'red', 'green', or 'blue'. The letters of the word are
capitalized and are approximately 2.5 cm tall. The stimulus word
is displayed on the screen on a black background such that it is
centered both horizontally and vertically. The response panel
has three buttons arranged in a horizontal row, one button is
colored red, one button in colored green, and the third button is
colored blue.

For all three of the versions of the test the stimulus word
remains on the screen until the subject makes a response.
Immediately following the subject's response, the screen is
blanked (totally black screen) until the following trial. An
inter-trial-interval follows the end of one trial and the
beginning of the next and lasts for 2 seconds. For all three of
the versions of the test the words, 'red', 'green', and 'blue'
are presented in a random order over 45 trials, arranged such
that each word appears for one third of the trials. For the word
relevant and color relevant versions, the presentation of the hue
for each of the three words is arranged such that each word
randomly appears in the hues, red, green, and blue, for one third
of their presentations. During the control version all
presentations of the words are displayed with a white hue.

Each word is presented in its completed form such that the
subject does not see the letters of the words drawn or painted
with the appropriate hues on the screen.

For each trial the time (to hundreds of seconds) that the
word is displayed on the screen and the time of the subject's

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responses is recorded. The correctness of the subject's response
is recorded as well as the actual button that the subject
pressed. The word presented and the hue of the word is recorded
for each trial. A recorded session also contains: the subject's
name or ID, the date, the version of the test, and the number of
trials completed. The above information can be used to generate
the following data analysis: percent correct, mean and variance
of congruent word and hue display time, mean and variance of
incongruent word and hue display time, test start time, and test
end time.

GRAMMATICAL REASONING TEST

Test Function:

The function of the Grammatical Reasoning test is to measure
general logical reasoning abilities and recognition of
relationships.

General Description of Test:

This test is based upon the procedure developed by Baddeley
(1968). During the test, pairs of letters are presented to the
subject along with brief statements about the sequential order of
the letter pairs. The subject is instructed to respond on one of
two buttons that indicate whether the statement about a given
letter pair is either true or false.

On each trial of the test, either the letter pair 'AB' or
'BA' is displayed along with a statement that either correctly or
incorrectly describes the order of the letters of a given pair.
For example, the subject may be presented with the letter pair,
'BA', and the statement, 'A IS FOLLOWED BY B' is presented, or
the subject may be presented 'AB', and the statement, 'B IS NOT
FOLLOWED BY A' is presented. The subject's task is to decide as
quickly as possible whether the statement about the letter pair

is true or false and press the corresponding button accordingly.
The first example above is false and the second example is true.
The subject is required to press the right button if the
statement is false and the left button if the statement is true.
A single trial consists of presenting a single pair of letters
and the statement about the pair and obtaining the subject's
responses. A test consists of a number of these trials or a
specified total amount of time.

Detailed Test Information:

A single trial consists of the presentation of a single
letter pair along with a statement regarding the pair and
obtaining the subject's response. A test lasts for 32 trials or
3 minutes, whichever occurs first.

On each trial the letter pair 'AB' or 'BA' is displayed on
the screen along with a statement, displayed on the left of the
same line, that correctly or incorrectly describes the sequence
of the letters within the pair. The displayed line is about half
way down from the top of the screen. The letter pair is shown on
the right of the line and the statement is shown on the left
ofthe same line. Two screen examples of letter pairs along with
the statements describing each pair are presented in Figures 3
and 4. White letters are used on a blue background. All letters
are presented in upper case in the screen text mode.

A given statement can differ along three different

Figure 3. Grammatical Reasoning test "AB" pair and statement.

Figure 4. Grammatical Reasoning Test "BA" pair and statement.

properties: (1) positive or negative statement, (2) active or passive statement, and (3) follow or precede verb root. The combinations of the properties produces the following eight sentences:

1.	follows	–	positive	active	follow
2.	precede	–	positive	active	precede
3.	is followed by	–	positive	passive	follow
4.	is preceded by	–	positive	passive	precede
5.	does not follow	–	negative	active	follow
6.	does not precede	–	negative	active	precede
7.	is not followed by	–	negative	passive	follow
8.	is not preceded by	–	negative	passive	precede

Each of these combinations can occur with either the letter pair, "AB" or "BA" and each letter pair can have either the letter order "AB" or "BA" within the statement. This produces a total of 32 unique combinations. Each of the 32 combinations are presented randomly over the total of 32 trials.

A presentation of a letter pair and statement remains displayed until the subject presses either the left ("statement if true") or right ("statement is false") response button. The screen is then cleared of all letters (background remains blue) for one second and then the next combination is presented.

For each trial the time (in hundreds of seconds) that the letter pair and statement is displayed and the time of the

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subject's response is recorded. The correctness of the subject's response is recorded as well as the actual button (right or left) that the subject pressed. The letter pair, the order of the letter pair, and a code that identifies the statement according to the three properties outlined above are recorded for each trial. A data file contains also the subject's name or ID, the date, and the number of trials completed. The recorded information can be used to generate percent correct responses, mean and median response latencies, range and variability of response latencies, and test start and end times. Data can be analyzed as overall summaries or broken down into subcategories based on statement dimensions.

MANIKIN TEST

Test Function:

The function of the Manikin test is to measure the ability to perform image rotation and related transformation as well as recognition of spatial orientation.

General Description of Test:

In the Manikin test the subject must respond correctly to a human figure presented in a number of spatial orientations. The test is based on a procedure developed by Benson and Gedye (1963). The subject is instructed to respond to the presentation of a human figure (manikin) by responding on one of two buttons that indicate which hand of the figure holds a stimulus that is the same as a larger stimulus that surrounds the human figure. The human figure is shown in different orientations.

The manikin is a drawn human figure placed inside either a green circle or a red square outline. The green circle or red square outline is the sample stimulus. The figure holds a green circle in one hand and a red square in the other hand. The green circle and red square shown in the hands of the figure are the comparison stimuli. The subject's task is to determine whether

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the right or left hand holds the stimulus that matches the sample stimulus. The subject presses a right button if the right hand holds a stimulus (either green circle or red square) that is the same as the outline that surrounds the human figure (either a green circle or red square) or a left button if the left hand holds the matching stimulus. The human figure is presented either upright or upside down and either facing toward or away from the subject.

A single trial consists of presenting a drawing of the human figure in a given orientation and obtaining a response from the subject. The test consists of a number of trials, defined as the total number of trials or a specified amount of time.

Detailed Task Information:

A trial consists of the presentation of the manikin and the subject's response. A test lasts for 32 trials or 3 minutes, whichever occurs first.

On each trial the subject sees a human figure displayed on a black background in the center of the screen. The figure is presented in one of four orientations: (1) right side up, (2) upside down, (3) facing toward the subject, or (4) facing away from the subject. There are four possible orientations for the figure based on all combinations of orientation. The manikin is surrounded by either a green circle or a red square. The manikin and its surrounding outline are centered in the middle of

the screen area and occupy almost the total vertical screen space. The surrounding outline is either a thin green circle or a thin red square.

The human figure is drawn, in yellow on black, such that the arms are lowered so as to project through the surrounding outline at the axis of rotation and is also coincident with the waist of the figure. The figure has clearly defined facial features (hair line, beard, eyes, mouth, etc.) as well as other clothing detail (necktie, lapels, belt buckle, shirt pockets, etc.) to insure that the subject is able to discriminate the orientation of the figure. The comparison stimuli (either a small green circle or red square) are drawn at the ends of the arms at the axis of rotation of the surrounding sample outline. The comparison stimuli are totally filled with color. During half of the trials the small green circle is in the left hand and the small red square is in the right hand and during the other half of the trials the two comparison stimuli are reversed. The complete figure and stimuli are presented in completed form such that the subject does not see the figure constructed (drawn) on the screen. Two screen examples of figures and stimuli presentations are shown in Figures 5 and 6.

The figure remains displayed until the subject presses either the left or right response button. The screen is then cleared (darkened) for two seconds and the next figure is presented. The four different orientations of the figure, and the location of the comparison stimulus in either the right or
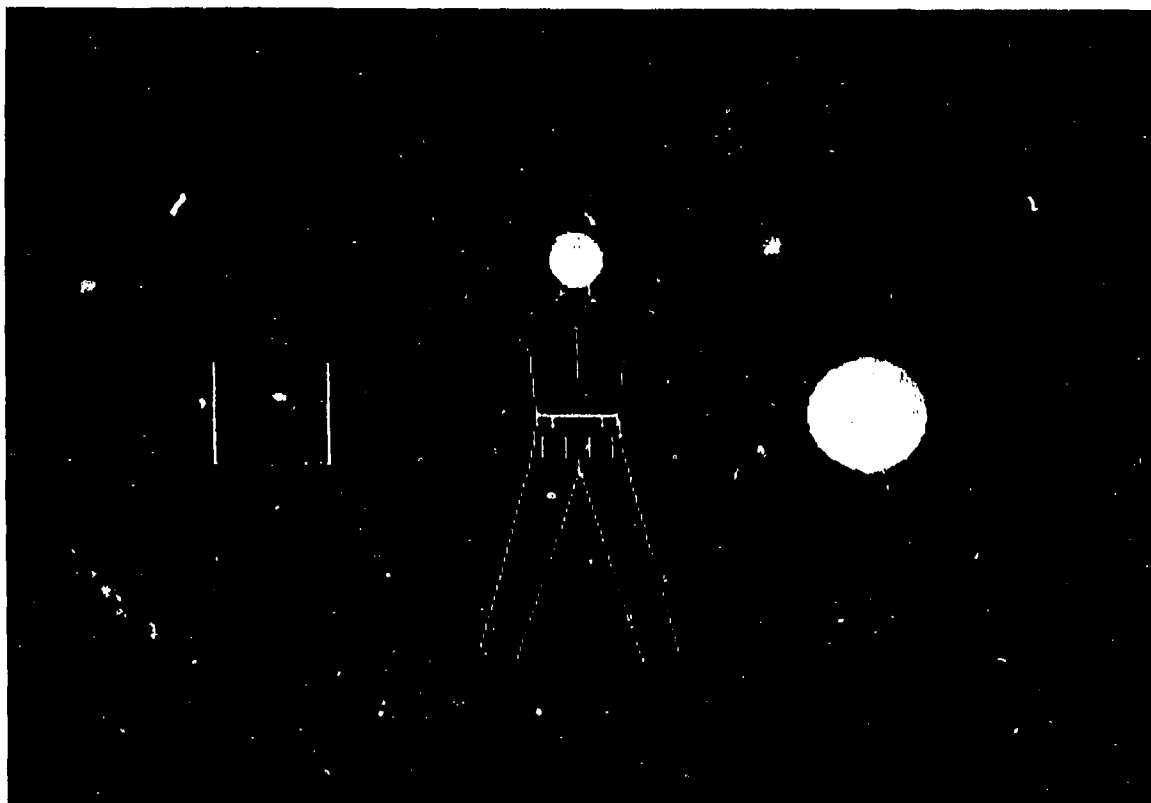
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Figure 5. Manikin test example with figure right side up, facing away, and surrounded by a square.
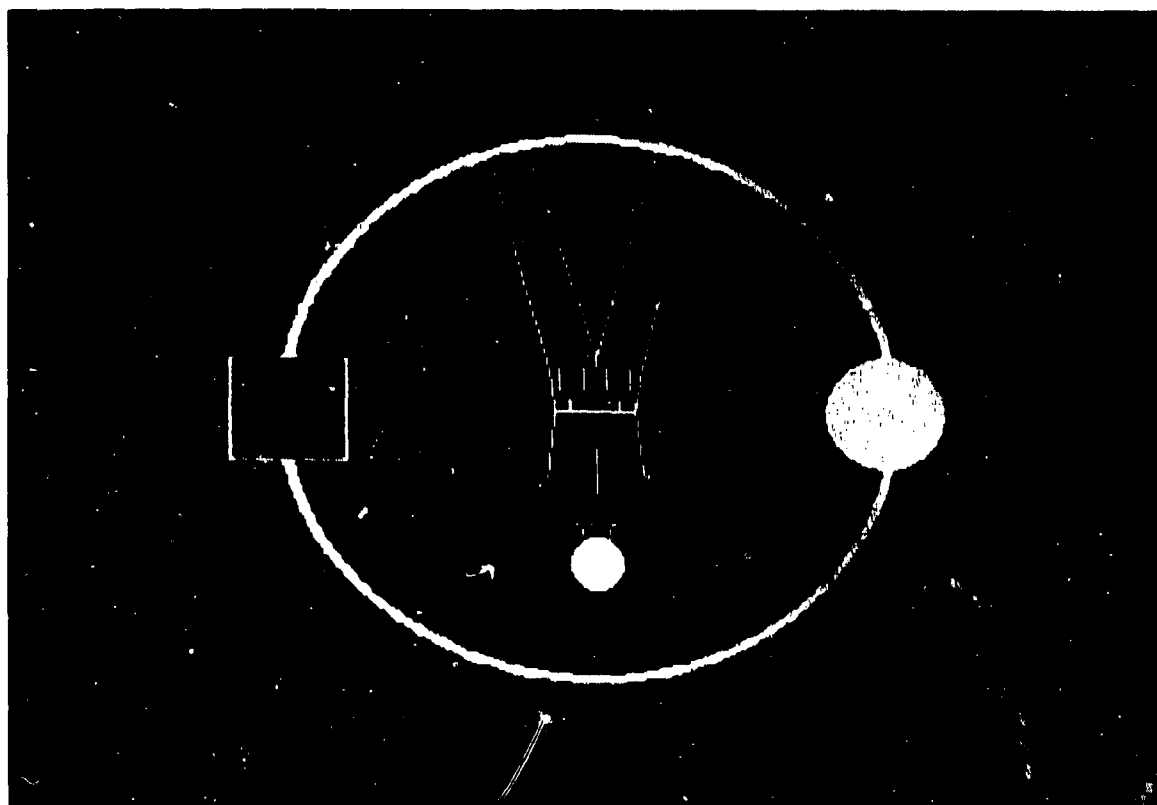
Figure 6. Manikin test example with figure upside down, facing away, and surrounded by a circle.

left hand produces 8 unique combinations. This set of 8 combinations can occur for either a red square or green circle surround for a total of 16 combinations. The 16 combinations of figure orientation, sample stimuli, and comparison stimuli location are randomly ordered and the set of 16 combinations is presented twice during a 32 trial test.

For each trial the time (in hundreds of seconds) that the figure is displayed on the screen and the time of the subject's response is recorded. The correctness of the subject's response is recorded as well as the actual button (left or right) that the subject pressed. The orientation of the figure, which sample stimulus surrounded the figure, and the location of the two comparison stimuli (held in left and right hand of the figure) is recorded for each trial. A data file also contains the subject's name or ID, the date, and the number of trials completed. The recorded information can be used to generate percent correct responses, mean and median response latencies, range and variability of response latencies, test start time, and test end time.

NUMERICAL MEMORY TEST

Test Function:

The function of the Numerical Memory test is to measure short-term numerical memory as well as recognition memory and encoding.

General Description of Test:

This test is a variation of a task reported by Sternberg (1969) which involved memory of alphabetic characters. In the present version the subject is required to remember a set of target numbers which appears briefly on the screen and to compare it with a single number presented a short time later. The subject then responds either "YES" or "NO", as quickly as possible, indicating whether the single number was included in the target number set. The subject is required to press the left button if the answer is "YES" and the right button if the answer is "NO". A single trial consists of the presentation of the target number set, followed by a brief delay by the single number, and the subject's response. A test consists of a number of trials, defined as a total number of trials or a specified total time.

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Detailed Test Information:

A test consists of the completion of 24 trials or the
passage of 3 minutes, whichever occurs first. A single trial
begins with the presentation of the target number set which
varies in length from one to four digits. Each possible number
set length (one, two, three, or four) appears equally often
during each session. The number set is presented as white
numerals on a blue background, centered on line 12 of a 24 line
by 80 column screen. The numbers are presented in medium
resolution (320 X 200 pixel graphics mode) graphics characters.
Figure 7 shows an example of a four digit number length set on
the screen. The number set remains on the screen for two seconds
after which the screen is cleared for three seconds.

Following the three second interval the single number
appears on the screen. The single number is presented as a
yellow number on a black background centered on line 12; its
dimensions are the same as the individual numbers in the number
set. During half of the trials the single number is the same as
one of the numbers previously presented in the number set and
during the other half of the trials, the single number is not
from the number set. The single number remains on the screen
until the subject presses either the left or right button. There
is no programmed interval between the subject's response and the
presentation of the next number set.

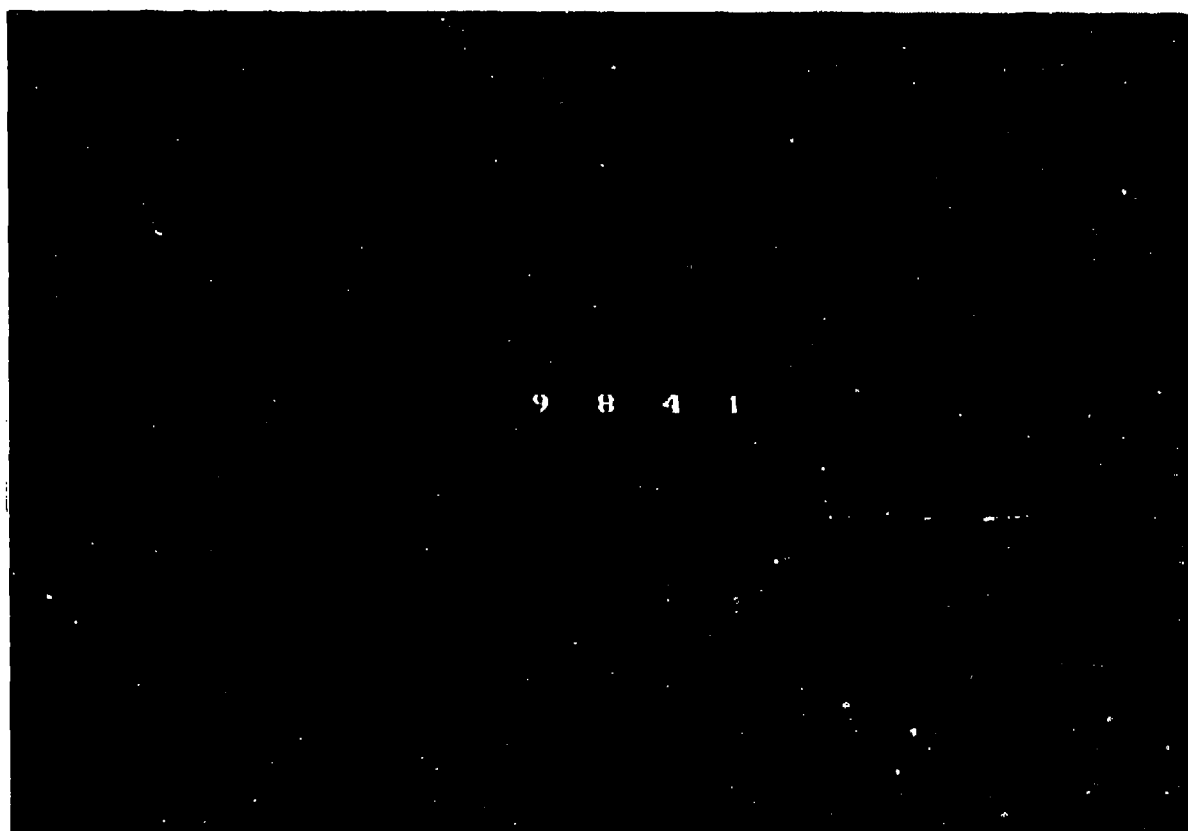The data collected during each trial consists of the elapsed

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Figure 7. Example of a four-digit number length set for Numerical Memory test.

time (in hundreds of seconds) from the appearance of the single
number to the subject's response, which button the subject
responded on, whether the response is correct or incorrect, the
identity of the numbers comprising the number set and their
sequence of appearance, and the identity of the single number. A
data file also contains the subject's name or ID, the date, and
the number of trials completed. The recorded information can be
used to generate percent correct responses, mean and median
response latencies, range and variability of responses latencies,
test start time, and test end time.

PATTERN COMPARISON TEST

Test Function:

The function of the Pattern Comparison test is to measure visual nonverbal pattern matching and ability to make pattern similarity judgments.

General Description of Test:

The Pattern Comparison test is based on a procedure reported by Klein and Armitage (1979). The subject is instructed to decide whether two dot patterns simultaneously presented are the same or different. The subject is initially presented with two patterns on the screen. The screen is divided in half vertically and a pattern of eight dots appears in each half of the screen. The subject's task is to determine, as fast as possible, whether the dot pattern in the right hand portion of the screen is the same as or different from the dot pattern in the left hand portion of the screen. The subject then responds on the "SAME" or "DIFFERENT" button of the response panel. A trial consists of a single presentation of the two comparison patterns and the subject's response. A test consists of a number of these trials, defined as a total number of trials or a specified total time.

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Detailed Test Information:

A test consists of the completion of 60 trials or the
passage of 3 minutes, whichever occur first. On each trial the
subject is presented with two patterns of cyan dots on a black
background. The patterns are bounded by a cyan border which
surrounds the entire raster area of the screen and divides the
screen vertically at the middle to form two equal rectangles.
Within each rectangle a random pattern of eight dots appears.
The complete dot patterns and borders are presented in completed
form such that the subject does not see the patterns constructed
or drawn on the screen. The restrictions are that no dot can
appear closer than 1.5 cm from any border and that no dot can
overlap any other dot. Two examples of the two dot patterns
presented on a trial are shown in Figures 8 and 9. The dot
patterns differ from each other in Figure 8 and are the same in
Figure 9. The patterns remain displayed until the subject
presses either the left or right response button. The screen is
cleared for 250 milliseconds following a response and the next
set of two patterns is then presented. The subject is to press
the left response button if the patterns are the same and to
press the right button if the patterns are different. During
half of the test trials the patterns are the same and during the
other half of the trials the patterns are different. The exact
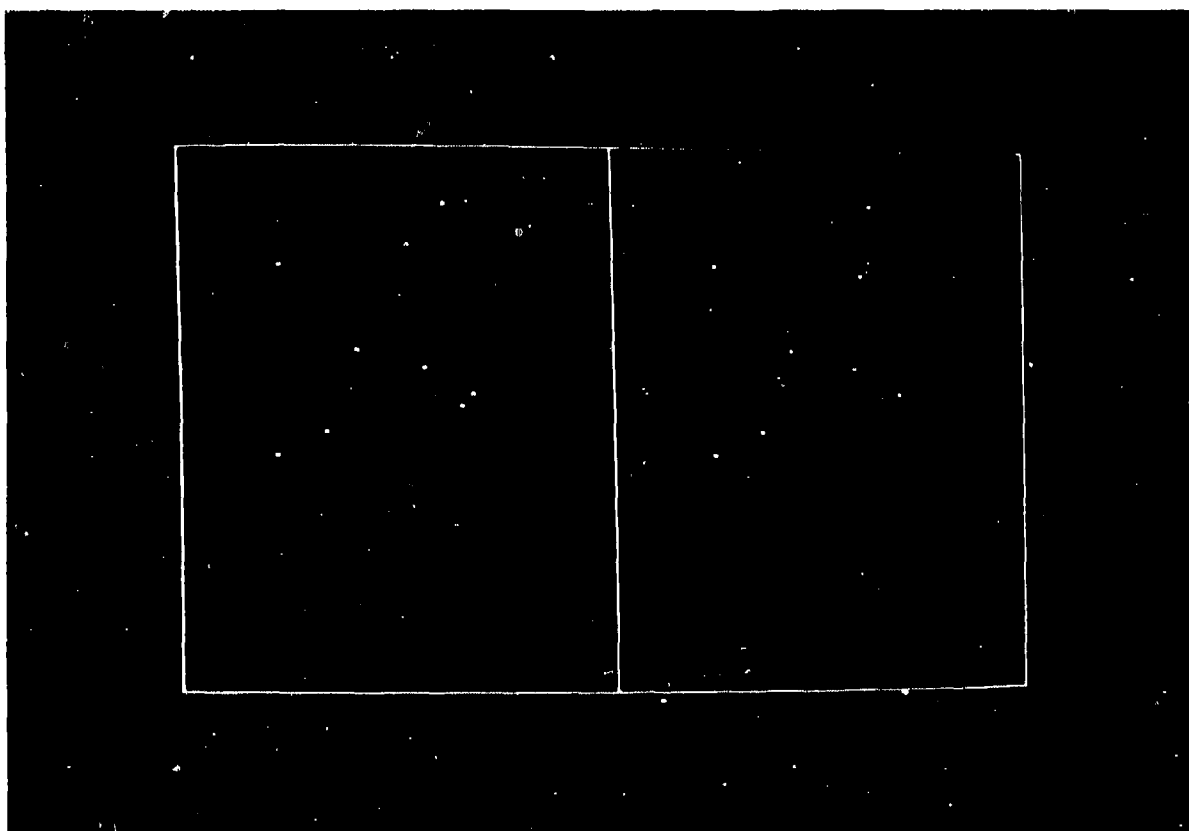sequence of same and different pattern trials is randomly

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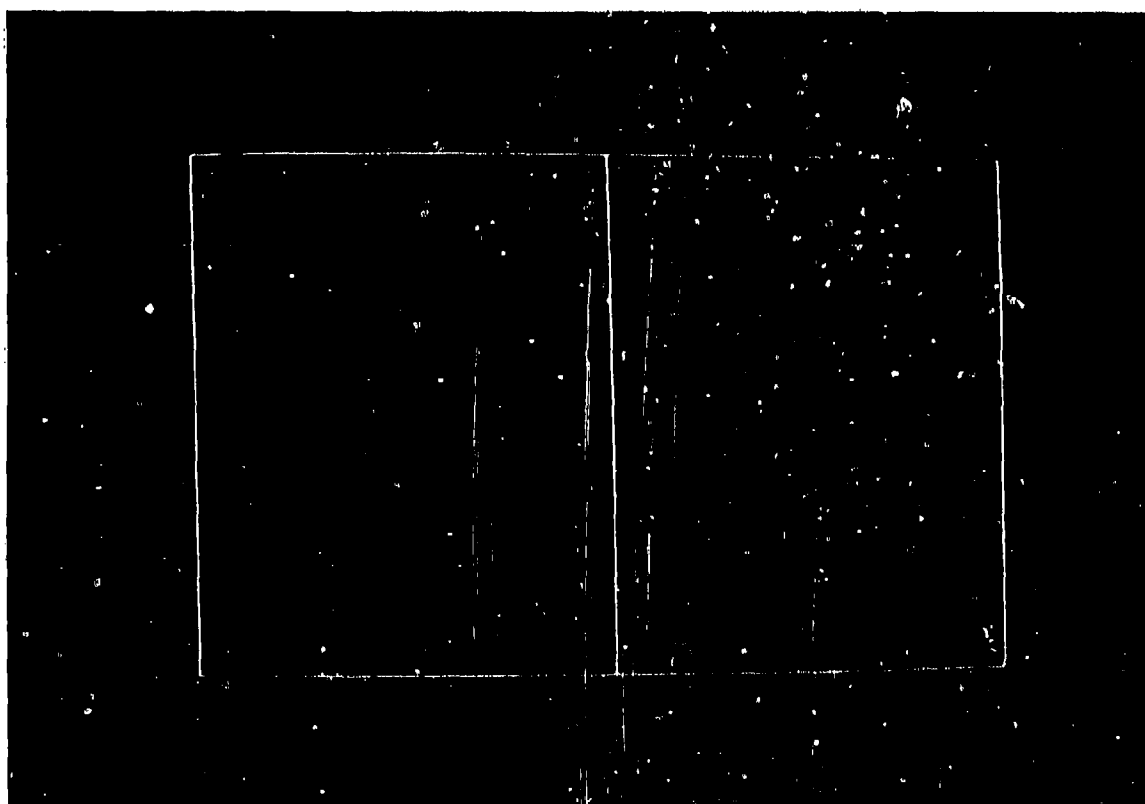Figure 8. Dot patterns for the Pattern Comparison test.

Figure 9. Dot patterns for the Pattern Comparison test.

ordered.

The data collected during any trial consist of the elapsed
time (in hundreds of seconds) between the appearance of the
stimulus display and the subjects response, whether the subject
responded on the 'SAME' or 'DIFFERENT' response button, and
whether the response was correct or incorrect. A data file also
contains the subject's name or ID, the date, and the number of
trials completed. The recorded information can be used to
generate percent correct responses, mean and median response
latencies, range and variability of responses latencies, and test
start and end times.

REPEATED ACQUISITION TEST

Test Function:

The function of the Repeated Acquisition test is to measure learning capability as well as short-term memory.

General Description of Test:

This test is based on the procedure described by Boren and Devine (1968). The subject's task during each session is to learn a specific sequence of responses by responding on a three button response panel in the appropriate order. In the NMRI-PAB implementation of the test the sequence is 12 members (button presses) long. The subject is to learn which of the three buttons (left, center, or right) is associated with each of 12 different rectangles presented on the computer screen. At the start of a trial, the subject is presented with a screen containing 12 empty rectangles. Each time a correct response is made a rectangle, beginning at the upper left, is filled in with color to indicate to the subject that a correct response was made and the sequence advances to the next member. This process is repeated until 12 correct button responses in the correct order are made and all 12 rectangles are filled. At the end of a

completed sequence the screen blanks briefly and the twelve empty rectangles reappear signaling the beginning of the next trial. The sequence is repeated, up to 25 times, to measure the learning of the button order sequence by the subject. The correct sequence of responses is usually changed from session to session by the experimenter so that the subject must learn a new sequence of responses during each session.

Detailed Test Information:

A single trial consists of the completion of a 12 member sequence of responses. A representative sequence to be learned might be the following three response button sequence: LRLCLRCRLRCR, where L=left, C=center, and R=right buttons. By repeatedly working through the sequence, over a number of trials, the subject is to learn the sequence of the order of the buttons to be pressed. The subject is instructed to respond as rapidly as possible to complete the sequence on each trial. One of 24 different sequences can be selected for each session. The sequence to be learned during a session is selected by the experimenter during the Executive program. The 24 different sequences that may be selected were generated in a random fashion with the restriction that no position could repeat itself and that the current sequence could not begin or end with the same position as the previous sequence. The sequence length to which the subject is exposed can also be manipulated, to be shorter or

longer than 12, by changing the value of a variable within the computer program.

When the session starts the subject is presented with a screen containing 12 empty rectangles, drawn in yellow lines on a black background. The 12 empty rectangles, as they appear on the screen, are shown in Figure 10. Each rectangle measures 4 cm wide by 3.5 cm wide and there are four rectangles on each row. They are separated horizontally by a 2.7 cm space and vertically by a 0.8 cm space. Each correct response causes the rectangle associated with that response to be filled in with red color in a left to right direction starting with the upper left rectangle. The subject is to learn which of the three buttons is associated with each of the 12 rectangles shown on the screen. When the correct button (left, center, or right) associated with the first rectangle is pressed, it is filled with red color. When the button associated with the second rectangle is correctly pressed, it is then filled. Figure 11 shows the set of 12 rectangles after two correct responses have been made and Figure 12 shows the set after nine correct responses. Each incorrect response causes the screen to go blank for one second, the screen reappears as it was prior to the incorrect response. The last correct response fills the last, lower right, rectangle. The screen is then cleared and the 12 empty rectangles reappear to signal the beginning of the next trial. This process is repeated until either 25 trials are completed or 5 minutes expires, whichever occurs first.
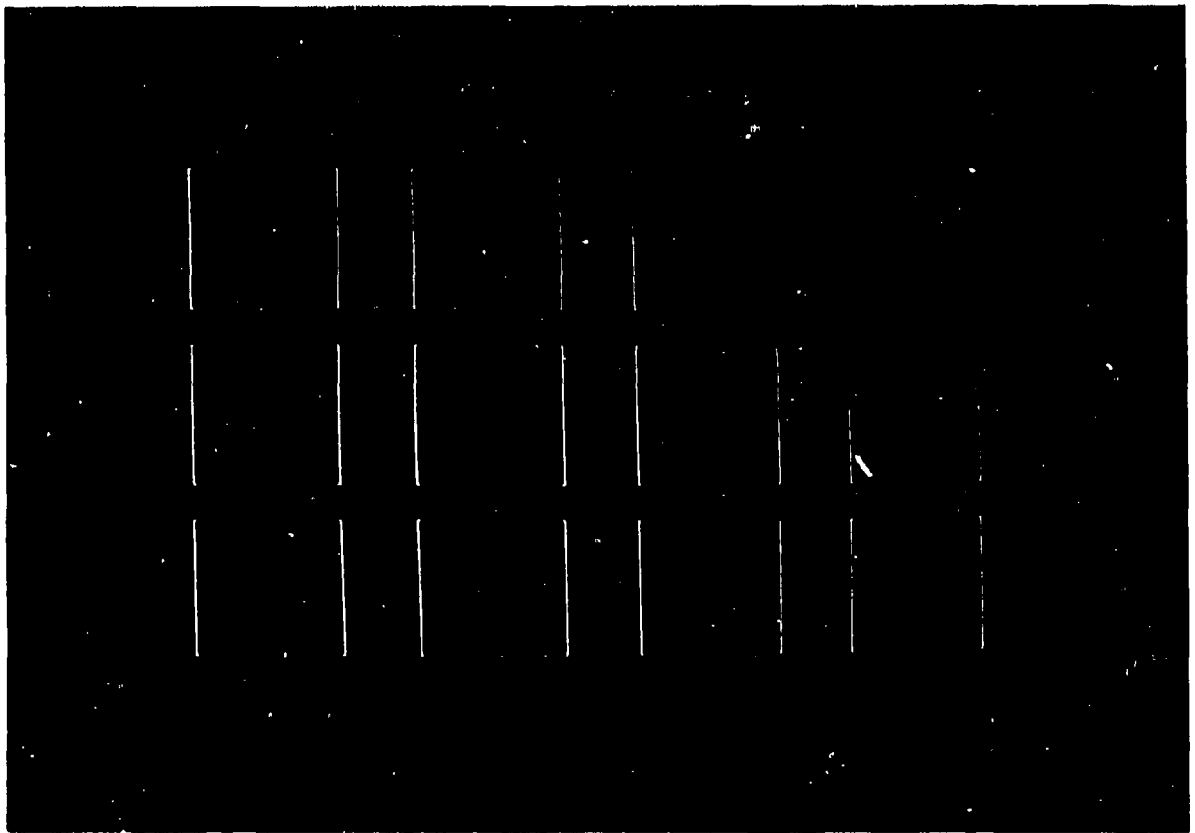
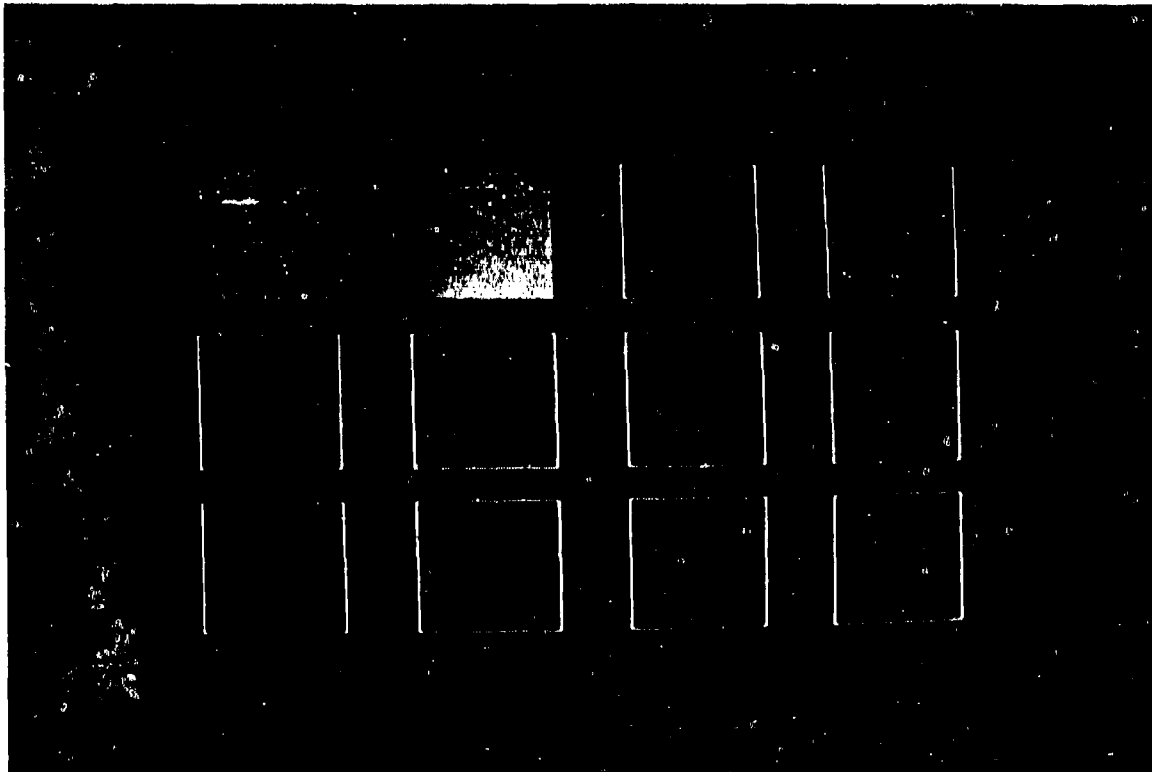Figure 10. Twelve empty rectangles for the Repeated Acquisition test.

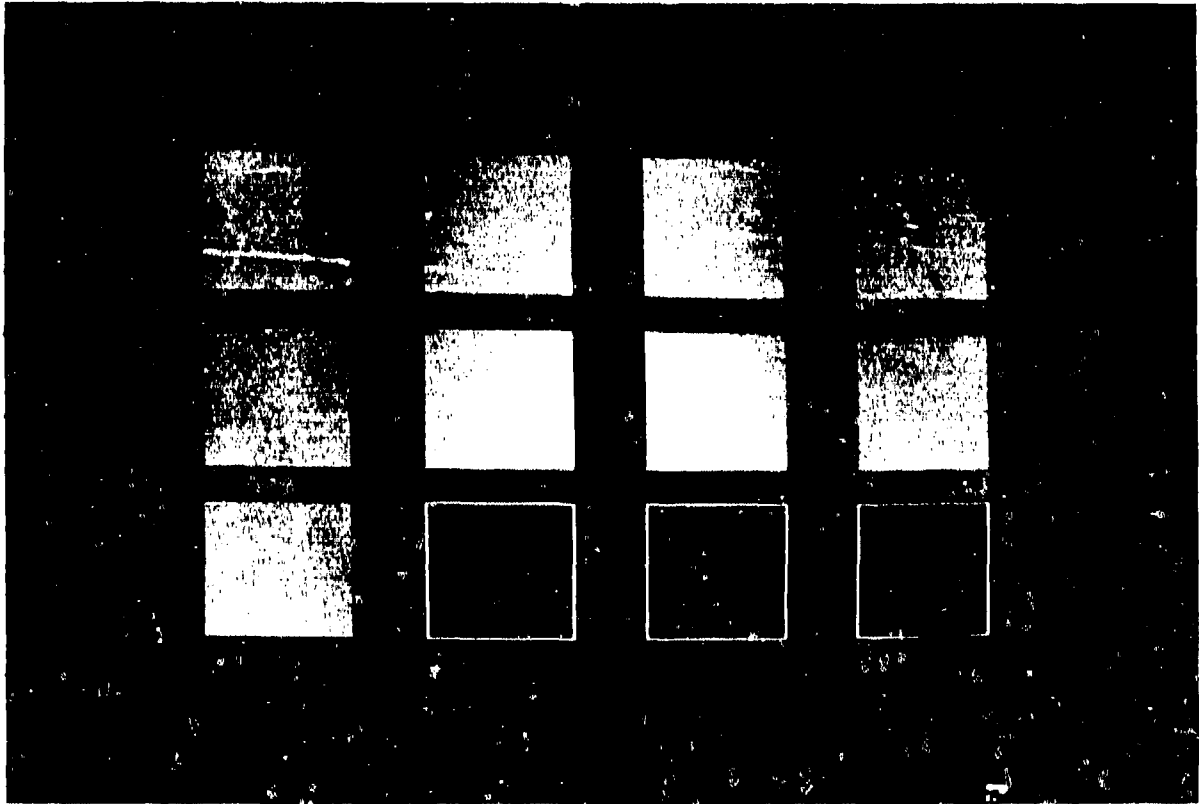Figure 11. Rectangles for Repeated Acquisition test after two correct responses.

Figure 12. Rectangles for Repeated Acquisition test after nine correct responses.

The data collected during each trial of this procedure include the response latency (in hundreds of seconds) from the last significant event (i.e. previous correct response, end of one-second blanking of screen following an incorrect response, or beginning of the sequence), the location of the button pressed (L,C,or R), and the current position in the 12 member sequence. During the test the data are stored and are written to the data file with a unique file name created by the program, along with subject identification information, at the end of the test. The data file also contains the learning sequence chosen for the test, the number of total responses, and the number of trials completed. The recorded information can be used to generate percent error responses, means and median response latencies, and test start and end times.

VISUAL SCANNING TEST

Test Function:

The function of the Visual Scanning test is to measure sustained attention, target recognition, and visual pattern discrimination.

General Description of Test:

The Visual Scanning test is a visual recognition task adopted from a test reported by Neisser (1963). In this test a single row of 20 letters is presented near the top of the screen. Three lines above the row of letters a pair of target letters are presented, centered on the screen. The subject's task is to determine, as quickly as possible, whether both of the target letters appear in the 20 letter row. If both of the target letters appear in the 20 letter row, the correct response is 'TRUE'. If only one or none of the 20 letter row letters appear as target letters, the correct response is 'FALSE'. Each test consists of a number of trials, defined as total number of trials or a specified total time.

Detailed Test Information:

A single trial consists of the presentation of the two target letters and the 20 letter row. Each test consists of 24 trials, or the passage of 3 minutes, whichever occurs first. All letters are presented in the upper case in the screen text mode, each letter occupies an area approximately 0.5 cm high by 0.3 cm wide. All letters appear as yellow on a black background. The target pair is centered on line 5 from the top of a 24 line screen, and the 20 letter row is centered on line 8. There are no spaces between letters. During half of the trials both of the target letters appear in the 20 letter row and during the other half of the trials only one or none of the target letters appear in the 20 letter row. The order of the trials in which two target letters are from the 20 letter row is randomly determined. Figures 13 and 14 show two examples of the appearance of the target letters and the 20 letter row on the screen. A response, whether correct or incorrect clears the screen and presents the next trial. There is no programmed inter-trial-interval. The letters remain displayed until the subject presses either the left ("TRUE") or right ("FALSE") response button.

The data collected during each trial consist of the elapsed time (in hundreds of seconds) from the presentation of the stimulus complex to the occurrence of a response, whether the response is correct or incorrect, whether both target letters are included in the 20 letter row or not, and the identity of the target letters. A data file also contains the subject's name or

Figure 13. Example of target letters and 20 letters row for the Visual Scanning test.
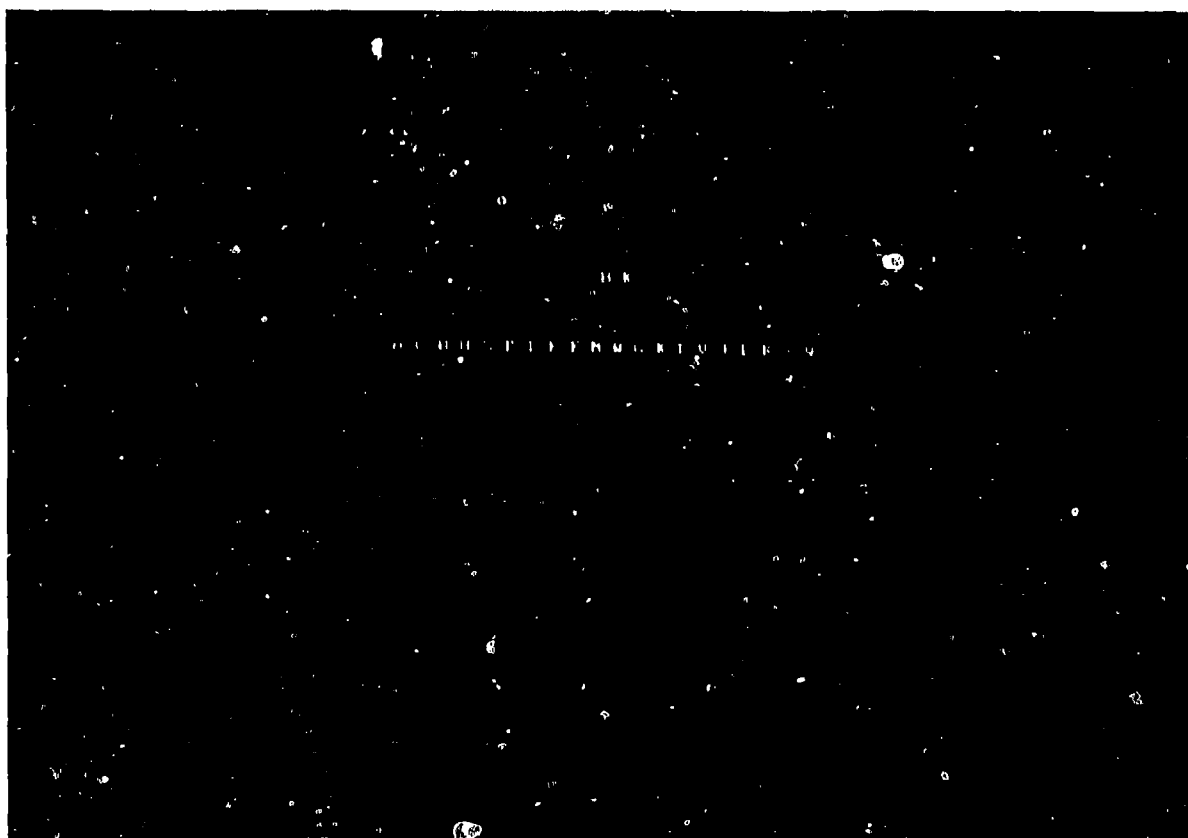
Figure 14. Example of target letters and 20 letter row for the Visual Scanning test.

ID, the date, and the number of trials completed. The recorded

information can be used to generate percent correct responses,

means and median response latencies, range and variability of

response latencies, and test start time and test end time.

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FIGURE LEGENDS

Figure 1. Representative sample stimulus for the Matching to Sample test. This figure and all figures are photographs of the computer screen.

Figure 2. Representative comparison stimuli for Matching to Sample test.

Figure 3. Grammatical Reasoning test 'AB' pair and statement.

Figure 4. Grammatical Reasoning test 'BA' pair and statement.

Figure 5. Manikin test example with figure right side up, facing away, and surrounded by a square.

Figure 6. Manikin test example with figure upside down, facing away, and surrounded by a circle.

Figure 7. Example of a four-digit number length set for Numerical Memory test.

Figure 8. Dot patterns for the Pattern Comparison test.

Figure 9. Dot patterns for the Pattern Comparison test.

Figure 10. Twelve empty rectangles for the Repeated Acquisition test.

Figure 11. Rectangles for Repeated Acquisition test after two correct responses.

Figure 12. Rectangles for Repeated Acquisition test after nine correct responses.

Figure 13. Example of target letters and 20 letter row for the Visual Scanning test.

Figure 14. Example of target letters and 20 letter row for the Visual Scanning test.